HOW TO FIND THE TIME AT SEA IN LESS THAN A MINUTE;

BEING

NEW AND ACCURATE METHODS,

WITH SPECIALLY ADAPTED

TABLES.

BY

A. C. JOHNSON, R.N.

AUTHOR OF

"On finding the Latitude and Longitude in Cloudy Weather," &c.

FIFTH EDITION.

London:

PUBLISHED BY J. D. POTTER,

Admiralty Agent for Charts,

145, MINORIES, E.

1907.

TWO SHILLINGS AND SIXPENCE.

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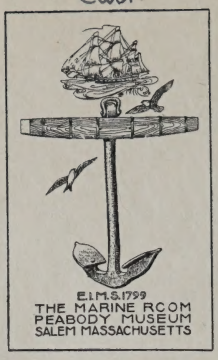

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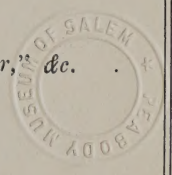

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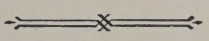
PREFACE TO THE FIFTH EDITION.



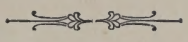
The Tables (A) (B) (C) as given in this edition, are intended for general use and although contracted so that all the logs requisite for working a "Chronometer" are displayed at one view, the time may be found by them within a second or two of that obtained by the ordinary rules. The special Table (D) may be used when the sky is clear, and the observation can be taken in the manner indicated; the advantage of this being that *only a single logarithm has to be looked out after the observation has been taken*, so that finding the time is reduced to the most simple and expeditious process in the whole range of nautical astronomy (*vide* p. 8), while in point of accuracy it is not inferior to the former method.

The very favourable notice accorded to these little tables by Lieut. English, R.N., in his highly scientific and valuable articles on Navigation which have from time to time appeared in the "Field" newspaper, and the marked approval which they have met with from numerous officers of our own and foreign services, as well as from the mercantile marine, have encouraged the author to introduce into this edition sundry alterations and improvements which he hopes will still further add to the usefulness of the book.

Dartmouth, 1907.

CONTENTS.

INTRODUCTION.



The practice of working out the sights for longitude with the D.R. latitude, and of subsequently correcting the resulting longitude for the error in this latitude, is, in the present day, generally followed. Now it will make no difference in the ultimate result if, instead of the D.R. latitude an *assumed* latitude approximating to it be used—the object being to reduce the meridian zenith distance (*which is the sum or difference of the latitude and declination, according as they are of opposite or like names*) to an *exact* number of degrees, so that it may correspond with the M.Z.D. in Table (D). For a like reason the altitude is taken to an exact degree, a matter of perfect simplicity to a practised observer, and, when taken, no further correction is necessary. Should, however, the weather be cloudy, and the altitude be taken in the usual way, we can easily correct the log. from Table (D) for the minutes of altitude, as shown on p. 12.

The observation is supposed to be taken under the usual conditions as to the bearing from the meridan, and to an exact degree by allowing the correction in altitude the opposite way. Thus for 20 ft. and 30°, the correction in altitude for the sun is + 10′ ; and if the index error be + 1′, the combined correction is + 11′. If, therefore, the sextant be set at 29° 49′, the *true* altitude of the Sun's centre will be 30° at the moment the lower limb is in contact with the horizon.

For a star the correction in altitude must be added instead of subtracted, but the index error must be applied as before. Thus, for 20 ft. and 30°, the correction in altitude is −6′, and if the index error be + 1′ the combined correction will be −5′ ; if, therefore, the index be set at 30° 5′, the true altitude will be 30° when the star is in contact with the horizon. The longitude deduced from the time thus found is to be corrected for the error in the *assumed* latitude in the usual way. (*Vide* p. 12.)

TO FIND THE TIME BY TABLE (D).

I.—Assume a latitude that will make the M.Z.D. an *exact* number of degrees,* and let this be called Lat. A.

II.—For this M.Z.D., and the altitude take out the logarithm from Table (D). This added to the log. secants of the assumed latitude and declination, will be the log. versine of the hour angle, which will be found in the part of Table (B) indicated by the *approximate time, or hour angle.*

If the body be East of Meridian, subtract the H.A. found as above from 24 hours.

The longitude deduced from this time is to be corrected for the error in the *assumed* latitude by Table (E).

EXAMPLES.

I.—Lat. D.R. 30° 25′ N. Dec. 19° 45′ S. Alt. 28°.

Lat. A.	30° 15′ N.	log sec.	636
Dec.	19 45 S.	,, ,,	263
M.Z.D.	50 0	log tab. (D)	2388
Alt.	28 0		
H.A.	2h. 32m. 27s.	log vers.	3287

II.—Lat. D.R. 52° 20′ N. Dec. 1° 30′ N. Alt. 19°.

Lat. A.	52° 30′ N.	log. sec.	2156
Dec.	1 30 N.	,, ,,	1
M.Z.D.	51 0	log. tab. (D)	4825
Alt.	19 0		
H.A.	3h. 59m. 44s.	....log vers.	6982

The assumed latitude need not differ from the D.R. latitude by more than 30′, and will not, therefore, affect the accuracy of the result.

On the next page is shown the practical application of the above in finding the longitude at noon, and the longitude corresponding to the D.R. latitude.

---

* To do this make the minutes of latitude equal to the minutes of declination, when they are of the *same* name, and when they are of contrary names subtract the minutes in the declination from 60′ to obtain the minutes of assumed latitude.

III.—At 8.30 A.M., in lat. D.R. 40° 35′ N., G.A.T. by chronometer 22h. 20m. 20s., true alt. ⊙ 30°, run to noon N.N.W. 30′, lat. by mer. alt. at noon 40° 52′ N. Required the true longitude at noon.

Lat. A.	40′	30′ N.	1190	Az. by TABLES.*	
Dec.	3	30 N.	8		
M.Z.D.	37	0	4751	Lat. 40° N. / H.A. 3.30	=S. 66° E.
Alt.	30	0			
H.A.	3h.	30m. 40s.	5949		
S.A.T.	20	29 20			
G.A.T.	22	20 20			
	1	51 0			

= 27° 45′ W., at 8.30 A.M. (long. A)

How to find the longitude simultaneously with the latitude at NOON.

Lat. A.	40° 30′ N.	Long. A.	27° 45′ W.
Run	28 N.	Run	15 W.
Approx. lat.	40 58 N.	Approx. long.	28 0 W.
Lat. mer. Alt.	40 52 N.	Cor. ·58 × 6	3½ W.
Corr.	6 S.	True long.	28 3½ W.

If it were required to find the longitude corresponding to the D.R. latitude at 8.30 A.M., we should have:—

Lat. A.	40° 30′ N.	Long. A.	27° 45′ W.
D.R.	40 35 N.	Corr. ·58 × 5	3 E.
Corr.	5 N.	Approx. long. at 8.30	27 42 W.

The correction for longitude, ·58′, is taken from Table (E).

To name the correction for the longitude, *vide* page 12.

The bearing found by Azimuth Table, when exceeding 90°, must be subtracted from 180°, and reckoned from the opposite point—thus, N. 120° W. would be S. 60° W., &c.

* Those given in "Cloudy Weather" may be used for this purpose.

To find the position AT NOON by the Chart.

Through the point given by the *approximate* latitude and longitude at *noon*, draw the position line, or (in this case) the line at right angles to S. 66° E. Then where this is cut by the parallel of the *true* latitude will be the true place of the ship.

To explain how in actual practice the Time may be found IN A FEW SECONDS.

As the declination, and therefore the assumed latitude which depends on it, are known before the observation is taken, we are already provided with the M.Z.D., and the two log secants; a *single* logarithm only will then be required to complete the process. Thus, in Ex. I., p. 6, the declination being 19° 45′ S., and the ship between 30° N. and 31° N., it is evident that the assumed latitude must be 30° 15′ N., therefore we have—

Lat. A.	30° 15′ N.	636
Dec.	19 45 S.	263
M.Z.D.	50 0	899 N.

Having subsequently observed the altitude to be 28° we have—

	N.	899	
Log. tab. (D)		2388	
			h. m. s.
Log. vers.		3287 =	2 32 27

The time is thus found in *a few seconds* and with sufficient accuracy for all practical purposes at sea.

Application of the above Principle to finding the Position by TWO OBSERVATIONS.

Let us suppose that the foregoing observation has been taken; that the longitude deduced from it is 20° 45′ W., and that the ship has run E.S.E. 22′ till 4.30 P.M., we have:—

Lat. A.	30° 15′ N.	Long. A.	20° 45′ W.
Run	8 S.	Run	23 E.
Lat. B.	30 7 N.	Long. B.	20 22 W.

The declination being now 19° 47′ S., suppose, and the ship being between lat. 30° and 31° N., we assume 30° 13′ N. for lat. C. Hence we have :—

Lat. C.	30° 13′ N.	635	
Dec.	19 47 S.	264	
M.Z.D.	50 0	899	(N.)

The second altitude is now taken, and is found to be 8°, therefore, as before :—

	N.	899		
Log. tab. (D)		7021	h. m. s.	
		7920	= 4 30 32	

Now, supposing that the longitude resulting from this time is 20° 52′ W. (or long. C), we have then :—

	Lats.	Longs.	Az.	Position Lines.
B	30° 7′ N.	B 20° 22 W.	S. 41° W.	N. 49° W.
C	30 13 N.	C 20 52 W.	S. 61 W.	N. 29 W.

Laying down B and C on the chart, and drawing the corresponding position lines, the point in which they intersect will be the true place of the ship at the time of the *second* observation.

The above principle is equally applicable to two stars, taken in the morning or evening twilight, either simultaneously or in quick succession ; and, as it involves only about a quarter of the work of an ordinary '*Sumner*,' and will give just as good results, it is strongly commended to the notice of the practical navigator.

Obs.—The difference of bearing should not be less than $1\frac{1}{2}$ or 2 points ; and, as a general rule, should exceed the less bearing. This applies to all heavenly bodies.

To find the Time SIMULTANEOUSLY with the Altitude.

As shown on page 8, we can determine beforehand the M.Z.D. and N.; we can therefore take out the H.A. for a few consecutive degrees, which will include the altitude at the time we wish to take the observation.

Thus, for M.Z.D. 50°, N. 899, and altitudes 29°, 30°, 31°, we have:

899	899	899
1986	1547	1064
2885	2446	1963

(*a*) 2h. 25m. 18s. (*b*) 2h. 17m. 53s. (*c*) 2h. 10m. 14s.

If, therefore, the true altitude is found to be either of the above degrees, the corresponding H.A. is known *without further calculation.*

The altitudes to be selected will, of course, depend on the time at which it is intended to take the observation. Suppose, for instance, we fix upon 8 A.M., and that the M.Z.D. is 50°, and N. 899, as before. Subtracting N. from the log vers. H.A., we look for the remaining log under the M.Z.D. 50°, in Table (D), when in a line with it we find the altitude thus:—

Log. vers. 4h.	= 6990	Tab. (C).
N.	= 899	
Log. alt.	= 6091	

Now, in the column M.Z.D. 50°, we find that 6091 comes between the logs. of 13° and 14°. Hence we may select 13°, 14°, and 15°, for which we take out the time, as above.

So that, if required, while one person is taking the altitude, a second may be finding the time from the Tables.

If, owing to clouds, the altitude cannot be observed as explained, the log. from Table (D) may easily be corrected for the minutes of altitude, as shown on p. 12.

From the above hour-angles and altitudes may be found the Bearings, by the Azimuth Tables, and thence the Variation, &c., if required.

ON FINDING THE TIME BY TABLES (A), (B), (C).

(These Tables are to be used when the observation is taken in the usual way, and as they are all on the same opening, a great saving of time and trouble is thereby effected.)

From Table (A) are taken the nat. versines of the Z.D. and M.Z.D., and the H.A. corresponding to their difference.

The log. versine of this H.A., Table (C), added to the log, secants of latitude and declination, Table (B), will be the log. versine of the H.A., to be taken from the part of Table (C), indicated by the *approximate* time.

EXAMPLES.

I.—At about 4h. 40m. P.M., in lat. 10° 35′ N., ⊙Z.D. was 76° 32′, and declination 23° 23′ S.

		Lat. 10° 35′ N.	74 sec.
Tab. A.		Dec. 23 23 S.	372 ,,
N. Vers.	1706	M.Z. 33 58	
,,	7672	Z.D. 76 32	
Diff.	5966†...	4h. 24m. 49s.	7756 log vers.
	H.A.	4 40 46	8202 ,,

II.—At about 4h. 10m. P.M., in lat. 10° 5′ N., ⊙Z.D. was 63° 35′, and declination 23° 19′ N.

		Lat. 10° 5′ N.	67* sec.
Tab. A.		Dec. 23 19 N.	370* ,,
N. Vers.	266*...	M.Z. 13 14	
,,	5551	Z.D. 63 35	
Diff.	5285	4h. 7m. 28s.	7230 log. vers.
	H.A.	4 21 48	7667 ,,

When the sun is west of mer. the H.A. is *apparent time.* When east, subtract the H.A. from 24 hours.

When the sum of the logs. exceeds four figures, reject the fifth figure on the left.

The parts marked with an asterisk may be written down before the observation is taken, thus enabling the remaining part of the calculation to be quickly gone through.

In using Table (C) it may sometimes be required to subtract an apparently greater logarithm from one apparently less, in which case the latter must be increased by 10,000, which is done by prefixing 1.

Thus : $0026 - 9970 = 10026 - 9970 = 0056$.

† Here diff. 5966 gives 4h. 24m. 49s. by Table (A). And 4h. 24m. 49s. give log. vers. 7756 by Table (C). In Ex. II. 5285 gives 4h. 7m. 28s. by Table (A), and 4h. 7m. 28s. give log. vers. 7230 by Table (C).

TO FIND THE TIME BY A STAR.

Find the hour-angle as in either of the preceding examples; then to the star's H.A. add its R.A., and from the sum (increased, if necessary, by 24h.) subtract the R.A. of the mean Sun. The remainder will be mean time at ship. The longitude is then found in the usual way.

N.B.—If the star is East of meridian, subtract the H.A. found as above from 24 hours.

The star's bearing, when required, may be taken from Burdwood's Tables, or from "The Bearings of the Principal Bright Stars," by the Author, published by J. D. Potter, London, price 3s.

To take out the Log. from Table (D) when there are minutes in the Altitude.

Take the difference of the logs. for the two degrees of altitude between which the given altitude lies, multiply it by the minutes expressed as the decimal of a degree*, and subtract.

Thus for M.Z.D. 10° and Alt. 20° 24′	
We have for Alt. 20°	8081
Diff. 112 × ·4 =	45
Log. required	8036
Again, for M.Z.D. 4°, and Alt. 25° 20′	
We have	7596
Diff. 120 × ·33 =	40
Log. required	7556

As the logs. decrease, they are conveniently arranged for subtracting.

To correct the longitude for an error in the latitude.

Table (E) gives the correction for 1′ error in the latitude—this, multiplied by the latitude correction, will be the correction required.

To name the Correction.

Under the sun's bearing, at the time of observation, write the opposite bearing, and connect the letters diagonally,

Thus for Bearing N.W.
×
We have S.E.

---

* The multiplier may be taken from Table (D), p. 25.

Which shows that a North correction of latitude gives an East correction of longitude, and *vice versâ*.

Ex. lat 30° N. ⊙ Bearing N. 80° E., corr. of lat. 20′ S.

Lat. 30°, Az. 80° } = 0′·20 N.E. / S.W.

∴ The correction = ′·20 × 20 or 4′ E.

The name of the correction may also be found by reversing the first letter of the bearing, thus for N.E. we have S.E., showing that a corr. S. gives E. and *vice versâ*.

EXAMPLES FOR PRACTICE.

Finding the Hour-Angle by Table (D).

(1.)	Lat. assumed, 50° 30′ N.	Dec. 1° 30′ N.	Alt. 24°	H.A. about 3½ hrs.
(2.)	,, 40 45 S.	,, 10 15 N.	,, 15	,, 4 ,,
(3.)	,, 17 15 N.	,, 2 15 N.	,, 50	,, 2¼ ,,
(4.)	,, 30 40 N.	,, 1 20 S.	,, 44	,, 2¼ ,,
(5.)	,, 28 10 N.	,, 12 10 N.	,, 33	,, 4 ,,

ANSWERS.

(1.) 3h. 30m. 16s. (2.) 3h. 59m. 12s. (3.) 2h. 31m. 3s. (4.) 2h. 19m. 1s. (5.) 3h. 55m. 37s.

Finding the Hour-Angle by Tables (A), (B), (C).

(1).	True Lat. 50° 21′ N.	Dec. 12° 10′ N.	Alt. 40° 30′	H.A. about 2⅓ hrs.
(2).	,, 40 30 S.	,, 10 51 N.	,, 35 17	,, ,, 1¼ ,,
(3).	,, 20 10 N.	,, 10 20 N.	,, 50 15	,, ,, 2¾ ,,
(4).	,, 2 5 S.	,, 1 3 S.	,, 60 10	,, ,, 2 ,,

ANSWERS.

(1.) 2h. 34m. 33s. (2.) 1h. 21 m. 30s. (3.) 2h. 40m. 13s. (4.) 1h. 59m. 17s.

The M.Z.D. and N., having been previously determined; to find the Hour-Angle.

(1.)	M.Z.D. 50°	N. 295	Alt. 20°	H.A. about 3 hours.
(2.)	,, 43	N. 1216	,, 17	,, ,, 4¼ ,,
(3.	,, 45	N. 3126	,, 15	,, ,, 5¾ ,,

ANSWERS.

(1.) 3h. 9m. 12s. (2.) 4h. 20m. 54s. (3.) 5h. 41m. 52s.

Correcting Log. Table D, for Minutes.

(1.)	M.Z.D. 10°	Alt. 40° 20′
(2.)	,, 20	,, 13 29
(3.)	,, 30	,, 20 48

ANSWERS.

(1.) 5284. (2.) 5889. (3.) 7083.

Correcting the Longitude, for an Error in Latitude.

(1.)	Lat. 50° N.	Bearing S. 60° E.	Corr. for Lat. 20′ N.
(2.)	,, 40 S.	,, S. 70 W.	,, 10 S.
(3.)	,, 20 N.	,, N. 75 E.	,, 15 N.

ANSWERS—CORRECTIONS.

(1.) 18′ E. (2.) 5′ E. (3.) 4′ W.

EXPLANATION OF THE TABLES.

*When a logarithm has to be taken out in two parts, place the forefinger of the left-hand on one part and the pen on the other, when the two parts are easily added together at sight.**

* The parts for the minutes seldom exceed two figures, and frequently only a single figure is required to be added.

Tab. (A). *To take out Nat. Vers.* 31° 53′ : We have 30° at the side, and 1° 45′ at the top, or 31° 45′ = 1496, and the parts for 8′ (to make up 53′) are 12—which, being added, we have 1508 ; the Nat. Vers. required.

To take out Nat. Vers. 59° 25½′ : We have 55° at the side, and 4° 15′ at the top, or 59° 15′ = 4887, and the parts 10½′ (to make up 25½′) are 26—which, being added, we have 4913.

This Table is arranged in two parts. The second being supposed to be a continuation of the first from left to right,* so that any versine not appearing in the first part will be found in the second, and *vice versâ*.

To take out the time for Nat. Vers. 4188 : The Nat. Vers. next less is 4157, which gives 3h. 37m., and the diff., 31, gives 54 seconds : hence the time is 3h. 37m. 54s.

Conversely : The Nat. Vers. of 3h. 37m. 54s. is 4188, for 3h. 37m. gives 4157, and 54s. give 31—which, being added, we have 4118 as above.

Tables (B) and (C) are used in the same manner.

The use of Table (D) when there are minutes in the altitude is explained on p. 12.

To convert Arc into Time by Table (A).

Ex.—*Convert* 76° 40′ *into time* : We have 76° 30′ = 5h. 6m., and 10′ = 40s.
∴ 76° 40′ = 5h. 6m. 40s.

Conversely : 5h. 6m. 40° = 76° 40′, for 5h. 6m. = 76° 30′, and 40s. = 10′
∴ 5h. 6m. 40s. = 76° 40′.

For an Arc greater than 90° subtract 90° ; convert the remaining degrees into time and add 6h., and for time exceeding 6h., subtract 6 hrs., convert the remaining time into Arc and add 90°.

To find the Natural Versine of an Arc greater than 90° . Subtract the Nat. Vers. of its supplement from 19999.

Thus for 120° 30′ (*whose supplement is* 58° 30′) we have Nat. Vers. 59° 30′ = 4925.

∴ 19999 − 4925 = 15074 = Nat. Vers. 120° 30′

Conversely : *Nat. Vers.* 15074 = 120° 30′.
For 19999 − 15074 = 4925 = 59° 30′.
And 180° − 59° 30′ = 120° 30′.

---

* In the same way as Table B.

To convert a Nat. Vers. into a Log. Vers.:

E .—*Convert Nat. Vers.* 7168 into *a Log. Versine.*

By Table (A), Nat. Vers. 7168 = 4h. 54m. 12s. = Log. Vers. 8554, Table (C).*

III. To find the Hour-Angle of a Star, referred to the Meridian below the Pole.

To obtain the M.Z.D. in this case add together latitude and declination and subtract the sum from 180°, then proceed as before.

EXAMPLE.

Lat. 50° 20′ N.		Dec. 48° 30′ N.		Z.D. 79° 40′	
M.Z.D. 81° 10′	8465	Lat. 50° 20′	1950		
*Z.D. 79 40	8207	Dec. 48 30	1787		
Nat. Vers.	258	= Log. Vers.	4114		
H.A. 1h. 20m. 28s.	7851				

If the M.Z.D. exceeds 90°, find its Nat. Vers. as above.

As in this particular case the M.Z.D. will always be greater than the Z.D., it is written down first.

TABLES FOR CORRECTING THE OBSERVED ALTITUDE.

☉'s CORR. OF ALT. +										✳'s CORR. OF ALT. —									
	HEIGHT IN FEET.										HEIGHT IN FEET.								
A.A.	4	8	12	16	20	24	28	32	A.A.	A.A.	4	8	12	16	20	24	28	32	A.A.
6°	5′	5′	4′	4′	3′	3′	2′	2′	6°	6°	11′	11′	12′	12′	13′	13′	14′	14′	6°
7	7	6	5	5	4	4	3	3	7	7	9	10	11	11	12	12	13	13	7
9	8	7	7	6	6	5	5	5	9	9	8	9	9	10	10	11	11	11	9
10	9	8	7	7	6	6	6	5	10	10	7	8	9	9	10	10	10	11	10
15	10	10	9	9	8	8	7	7	15	14	6	6	7	7	8	8	9	9	15
20	11	11	10	9	9	9	8	8	20	20	5	5	6	7	7	7	8	8	20
30	12	11	11	11	10	10	9	9	30	30	4	5	5	5	6	6	7	7	30
50	13	12	12	11	10	10	10	10	50	50	3	4	4	5	6	6	6	6	50
70	14	13	12	12	11	11	10	10	70	70	2	3	4	4	5	5	6	6	70

* When there are fewer than four figures in the Nat. Vers. make them up to four by adding ciphers: thus, in following example, Nat. vers. 258 becomes 2580 = 2h. 48m. 20s. Tab. (A), = Log. Vers. 4114 Tab. (C).

TABLES.

Table (A) NAT.-VERSINES of M.Z.D. and Z.D.

Time.	Arc.	m 0	m 1	m 2	m 3	m 4	m 5	m 6	m 7	m 8	m 9
H. M.	°	° ′ 0 0	° ′ 0 15	° ′ 0 30	° ′ 0 45	° ′ 1 0	° ′ 1 15	° ′ 1 30	° ′ 1 45	° ′ 2 0	° ′ 2 15
0 0	0	0	0	0	0	2	2	3	5	6	8
20	5	38	42	46	50	55	59	64	69	75	80
40	10	152	160	167	175	184	192	201	210	219	228
1 0	15	341	352	364	376	387	399	412	424	437	450
20	20	603	618	633	649	664	680	696	712	728	745
40	25	937	956	974	993	1012	1031	1051	1070	1090	1110
2 0	30	1340	1362	1384	1406	1428	1451	1474	1496	1520	1543
20	35	1808	1834	1859	1884	1910	1936	1961	1987	2014	2040
40	40	2340	2368	2396	2424	2453	2482	2510	2539	2569	2598
3 0	45	2929	2960	2991	3022	3053	3085	3116	3148	3180	3212
20	50	3572	3606	3639	3673	3707	3741	3775	3809	3843	3878
40	55	4264	4300	4336	4372	4408	4444	4481	4517	4554	4590
4 0	60	5000	5038	5076	5114	5152	5190	5228	5267	5305	5344
20	65	5774	5813	5853	5893	5933	5973	6013	6053	6093	6133
40	70	6580	6621	6662	6703	6744	6786	6827	6868	6910	6951
5 0	75	7412	7454	7496	7538	7581	7623	7666	7708	7750	7793
20	80	8264	8306	8350	8393	8436	8479	8522	8565	8608	8651
40	85	9128	9172	9215	9259	9302	9346	9390	9433	9477	9520

PARTS.

s 1	s 4	s 8	s 12	s 16	s 20	s 24	s 28	s 32	s 36	s 40	s 44	s 48	s 52	s 56
′ ¼	′ 1	′ 2	′ 3	′ 4	′ 5	′ 6	′ 7	′ 8	′ 9	′ 10	′ 11	′ 12	′ 13	′ 14
								1	1	1	1	1	1	1
·1		1	1	1	2	2	2	2	3	3	3	4	4	4
·1	1	1	2	2	3	3	4	4	5	6	6	7	7	8
·2	1	2	2	3	4	5	6	6	7	8	9	10	11	11
·3	1	2	3	4	5	6	7	8	9	11	12	13	14	15
·3	1	3	4	5	6	8	9	10	12	13	14	15	17	18
·4	2	3	5	6	8	9	11	12	14	15	17	18	20	21
·4	2	3	5	7	9	10	12	14	15	17	19	21	22	24
·5	2	4	6	8	10	12	13	15	17	19	21	23	25	27
·5	2	4	6	8	10	13	15	17	19	21	23	25	27	29
·6	2	5	7	9	11	14	16	18	20	23	25	27	29	32
·6	2	5	7	10	12	15	17	19	22	24	26	29	31	34
·6	3	5	8	10	13	15	18	20	23	26	28	31	33	36
·7	3	5	8	11	13	16	19	21	24	27	29	32	35	37
·7	3	6	8	11	14	17	19	22	25	28	30	33	36	39
·7	3	6	8	11	14	17	20	23	25	28	31	34	37	40
·7	3	6	9	11	14	17	20	23	26	29	32	34	37	40
·7	3	6	9	12	15	17	20	23	26	29	32	35	38	41

Time.	Arc.	m 0	m 1	m 2	m 3	m 4	m 5	m 6	m 7	m 8	m 9
H. M.	°	° ′ 2 30	° ′ 2 45	° ′ 3 0	° ′ 3 15	° ′ 3 30	° ′ 3 45	° ′ 4 0	° ′ 4 15	° ′ 4 30	° ′ 4 45
0 10	0	10	12	14	16	19	21	24	27	31	34
30	5	86	91	97	103	110	116	123	130	137	144
50	10	237	247	256	266	276	287	297	308	319	330
1 10	15	463	476	489	503	517	531	545	559	574	588
30	20	761	778	795	812	829	847	865	882	900	919
50	25	1130	1150	1171	1191	1212	1233	1254	1275	1296	1318
2 10	30	1566	1590	1613	1637	1661	1685	1710	1734	1759	1784
30	35	2066	2093	2120	2147	2174	2201	2229	2256	2284	2312
50	40	2627	2657	2686	2716	2746	2776	2807	2837	2867	2898
3 10	45	3244	3276	3309	3341	3374	3407	3439	3472	3506	3539
30	50	3912	3947	3982	4017	4052	4087	4122	4157	4193	4229
50	55	4627	4664	4701	4738	4775	4812	4850	4887	4925	4962
4 10	60	5383	5421	5460	5499	5538	5577	5616	5656	5695	5734
30	65	6173	6214	6254	6294	6335	6376	6416	6457	6498	6539
50	70	6993	7035	7076	7118	7160	7202	7244	7286	7328	7370
5 10	75	7836	7878	7921	7964	8006	8049	8092	8135	8178	8221
30	80	8695	8738	8781	8825	8868	8911	8955	8998	9042	9085
50	85	9564	9607	9651	9695	9738	9782	9825	9869	9913	9956

PARTS.

s 1	s 4	s 8	s 12	s 16	s 20	s 24	s 28	s 32	s 36	s 40	s 44	s 48	s 52	s 56
′ ¼	′ 1	′ 2	′ 3	′ 4	′ 5	′ 6	′ 7	′ 8	′ 9	′ 10	′ 11	′ 12	′ 13	′ 14
			1	1	1	1	1	2	2	2	2	2	2	3
·1	1	1	1	2	2	3	3	4	4	4	5	5	5	6
·2	1	1	2	3	3	4	5	5	6	7	8	8	9	10
·2	1	2	3	4	5	6	7	7	8	9	10	11	12	13
·3	1	2	3	5	6	7	8	9	11	12	13	14	15	16
·3	1	3	4	6	7	8	10	11	13	14	15	17	18	20
·4	2	3	5	6	8	10	11	13	15	16	18	19	21	23
·5	2	4	5	7	9	11	13	15	16	18	20	22	24	26
·5	2	4	6	8	10	12	14	16	18	20	22	24	26	28
·5	2	4	7	9	11	13	15	17	20	22	24	26	28	31
·6	2	5	7	9	12	14	16	19	21	23	26	28	30	33
·6	2	5	7	10	12	15	17	20	22	25	27	30	32	35
·7	3	5	8	10	13	16	19	21	24	27	29	32	35	37
·7	3	5	8	11	14	16	19	22	24	27	30	33	35	38
·7	3	6	8	11	14	17	20	22	25	28	31	33	36	39
·7	3	6	9	11	14	17	20	23	26	29	31	34	37	40
·7	3	6	9	11	14	17	20	23	26	29	32	34	37	40
·7	3	6	9	12	15	17	20	23	26	29	32	35	38	41

Table (B) LOG-SECANTS of LAT. and DEC.

Deg.	° ′ 0 0	° ′ 0 15	° ′ 0 30	° ′ 0 45	° ′ 1 0	° ′ 1 15	° ′ 1 30	° ′ 1 45	° ′ 2 0	° ′ 2 15
0°					1	1	1	2	3	3
5	17	18	20	22	24	26	28	30	32	35
10	66	70	73	77	81	84	88	92	96	100
15	151	156	161	166	171	177	183	188	194	200
20	270	277	284	291	298	306	313	321	328	336
25	427	436	445	454	463	473	482	492	501	511
30	625	636	647	658	669	681	692	704	716	728
35	866	880	893	907	920	934	948	962	977	991
40	1157	1173	1190	1206	1222	1239	1255	1272	1289	1306
45	1505	1524	1543	1563	1582	1602	1622	1642	1662	1683
50	1919	1942	1965	1988	2011	2035	2058	2082	2107	2131
55	2414	2441	2469	2496	2524	2553	2581	2610	2639	2668

PARTS.

′ ¼	′ 1	′ 2	′ 3	′ 4	′ 5	′ 6	′ 7	′ 8	′ 9	′ 10	′ 11	′ 12	′ 13	′ 14
				1	1	1	1	1	1	1	1	2	2	2
·1		1	1	1	1	2	2	2	2	3	3	3	3	4
·1		1	1	1	2	2	3	3	4	4	5	4	4	5
·1	1	1	2	3	3	4	4	5	6	6	7	8	8	9
·2	1	2	2	3	4	5	5	6	7	8	8	9	10	11
·2	1	2	3	3	4	5	6	7	8	9	10	11	12	13
·3	1	2	3	4	6	7	8	9	10	11	12	13	14	16
·4	1	3	4	5	7	8	9	11	12	13	15	16	17	18
·5	2	3	5	6	8	9	11	13	14	16	17	19	21	22
·5	2	4	6	8	9	11	13	15	17	19	21	23	25	26

THE TIME AT SEA.

Table (C) LOG-VERS. HOUR-ANGLE.

H. M.	m 0	m 1	m 2	m 3	m 4	m 5	m 6	m 7	m 8	m 9
1 0	5824	5467	5607	5745	5881	6015	6147	6277	6404	6530
10	6654	6776	6897	7016	7133	7248	7362	7475	7586	7695
20	7804	7910	8016	8120	8223	8325	8425	8524	8622	8719
30	8815	8910	9003	9096	9188	9278	9368	9457	9544	9631
40	9717	9802	9886	9970	0052	0134	0215	0295	0374	0453
50	0530	0607	0684	0759	0834	0909	0982	1055	1127	1199
2 0	1270	1341	1410	1480	1548	1616	1684	1751	1817	1883
10	1948	2013	2077	2141	2204	2267	2329	2391	2452	2513
20	2573	2633	2692	2751	2810	2868	2926	2983	3040	3096
30	3152	3208	3263	3318	3372	3426	3480	3533	3586	3639
40	3691	3743	3795	3846	3897	3947	3997	4047	4097	4146
50	4195	4243	4292	4340	4387	4435	4482	4529	4575	4621
3 0	4667	4713	4758	4803	4848	4892	4937	4981	5024	5068
10	5111	5154	5197	5239	5281	5323	5365	5406	5447	5488
20	5529	5570	5610	5650	5690	5730	5769	5808	5847	5886
30	5924	5963	6001	6038	6076	6114	6151	6188	6225	6262
40	6298	6335	6371	6407	6442	6475	6513	6549	6584	6618
50	6653	6687	6722	6756	6790	6823	6857	6890	6924	6957
4 0	6990	7022	7055	7087	7120	7152	7184	7215	7247	7278
10	7310	7341	7372	7403	7433	7464	7494	7525	7555	7585
20	7615	7644	7674	7703	7732	7762	7791	7819	7848	7877
30	7905	7933	7961	7990	8017	8045	8073	8100	8128	8155
40	8182	8209	8236	8263	8289	8316	8342	8368	8395	8421
50	8447	8472	8498	8524	8549	8574	8600	8625	8650	8674
5 0	8699	8724	8748	8773	8797	8821	8845	8869	8893	8917
10	8941	8964	8988	9011	9034	9059	9080	9103	9126	9149
20	9172	9194	9217	9239	9261	9283	9305	9327	9349	9371
30	9393	9414	9436	9457	9478	9499	9520	9541	9562	9583
40	9604	9625	9645	9666	9686	9706	9726	9746	9766	9786
50	9806	9826	9846	9865	9885	9904	9923	9943	9962	9981
6 0	0000	0019	0038	0056	0075	0094	0112	0130	0149	0167
10	0185	0203	0221	0239	0257	0275	0293	0310	0328	0345
20	0363	0380	0397	0415	0432	0449	0466	0482	0499	0516
30	0533	0549	0566	0582	0598	0615	0631	0647	0663	0679
40	0695	0711	0727	0743	0758	0774	0789	0805	0820	0836
50	0851	0866	0881	0896	0911	0926	0941	0956	0970	0985

PARTS.

s 1	s s s 4 8 12	s s s 16 20 24	s s s 28 32 36	s s s 40 44 48	s s 52 56
2	9 18 27	35 44 55	62 71 80	89 97 106	115 124
2	8 13 23	31 38 46	54 61 69	77 84 92	100 107
2	7 13 20	27 34 40	47 54 61	67 74 81	87 94
2	6 12 18	24 30 36	42 48 54	60 66 72	78 84
1	5 11 16	22 27 32	38 43 49	54 59 65	70 76
1	5 10 15	20 25 30	35 39 44	49 54 59	64 69
1	4 9 14	18 23 27	32 36 41	45 50 54	59 63
1	4 8 12	17 21 25	29 33 37	41 46 50	54 58
1	4 8 12	15 19 23	27 31 35	39 42 46	50 54
1	4 7 11	14 18 22	25 29 32	36 40 43	47 50
1	3 7 10	13 17 20	23 27 30	33 37 40	43 47
1	3 6 9	12 16 19	22 25 28	31 34 38	41 44
·7	3 6 9	12 15 18	20 23 26	29 32 35	38 41
·7	3 6 8	11 14 17	20 22 25	28 31 34	36 39
·7	3 5 8	10 13 16	18 21 23	26 29 31	34 36
·6	2 5 7	10 12 15	17 20 22	25 27 30	32 34
·6	2 5 7	9 12 14	16 19 21	25 26 28	30 33
·6	2 4 7	9 11 14	16 18 20	23 25 27	29 32
·6	2 4 6	8 11 13	15 17 19	21 23 26	28 30
·5	2 4 6	8 10 12	14 16 17	20 22 24	26 28
·5	2 4 6	8 10 12	13 15 17	19 21 23	25 27
·5	2 4 5	7 9 11	13 15 17	19 20 22	24 26
·4	2 3 5	7 9 10	12 14 16	17 19 21	22 24
·4	2 3 5	7 8 10	12 13 15	17 18 20	22 23
·4	2 3 5	6 8 10	11 13 14	16 18 19	21 22
·4	1 3 5	6 8 9	11 12 14	15 17 18	20 22
·4	1 3 4	6 7 9	10 12 13	15 16 18	19 21
·4	1 3 4	6 7 8	10 11 13	14 15 17	18 20
·3	1 3 4	5 7 8	9 11 12	13 15 16	17 19
·3	1 2 4	5 6 8	9 10 11	13 14 15	16 18
·3	1 2 4	5 6 7	8 10 11	12 13 14	16 17
·3	1 2 3	4 6 7	8 9 10	11 12 14	15 16
·3	1 2 3	4 6 7	8 9 10	11 12 14	15 16
·3	1 2 3	4 5 6	7 8 10	11 12 13	14 15
·3	1 2 3	4 5 6	7 8 10	11 12 13	14 15
·3	1 2 3	4 5 6	7 8 10	11 12 13	14 15

Table (B) LOG-SECANTS of LAT. and DEC.

Deg.	° ′ 2 30	° ′ 2 45	° ′ 3 0	° ′ 3 15	° ′ 3 30	° ′ 3 45	° ′ 4 0	° ′ 4 15	° ′ 4 30	° ′ 4 45
0	4	5	6	7	8	9	11	12	13	15
5	37	40	42	45	48	51	54	57	60	63
10	104	108	113	117	122	126	131	136	141	146
15	206	212	218	224	230	237	243	250	257	263
20	344	352	360	368	376	384	393	401	410	418
25	521	531	541	551	561	571	582	592	603	614
30	740	752	764	776	789	802	814	827	840	853
35	1005	1020	1035	1050	1065	1080	1095	1110	1126	1142
40	1324	1341	1359	1376	1394	1412	1431	1449	1468	1486
45	1703	1724	1745	1766	1787	1809	1831	1852	1874	1897
50	2156	2180	2205	2231	2256	2282	2308	2334	2360	2387
55	2698	2728	2758	2788	2819	2850	2882	2913	2945	2978

PARTS.

′ ¼	′ 1 2	′ 3 4 5	′ 6 7 8	′ 9 10 11	′ 12 13 14
			1 1 1	1 1 1	1 1 1
	1	1 1 1	1 1 2	2 2 2	2 2 3
·1	1	1 1 2	2 2 3	3 3 4	4 4 4
·1	1	1 2 3	3 3 3	4 4 5	5 6 6
·1	1 1	2 3 3	3 4 4	5 6 6	7 7 8
·1	1 1	2 3 3	4 5 6	6 7 8	8 9 10
·2	1 2	3 3 4	5 6 7	8 8 9	10 11 12
·2	1 2	3 4 5	6 7 8	9 10 11	12 13 14
·3	1 2	4 5 6	7 8 10	11 12 13	14 16 17
·4	1 3	4 6 7	9 10 12	13 14 16	17 19 20
·5	2 3	5 7 9	10 12 14	15 17 19	21 22 24
·5	2 4	6 8 10	12 15 17	19 21 23	25 27 29

Table (D). MERIDIAN ZENITH-DISTANCE.

Alt.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	Alt.
5°	9604	9603	9601	9597	9592	9586	9578	9568	9557	9545	9531	9516	5°
6	9521	9520	9518	9514	9509	9502	9494	9484	9473	9460	9446	9430	6
7	9436	9435	9433	9429	9424	9417	9408	9399	9387	9374	9360	9344	7
8	9349	9348	9346	9342	9337	9330	9321	9311	9300	9287	9272	9255	8
9	9261	9260	9258	9254	9249	9242	9233	9223	9211	9197	9182	9166	9
10	9172	9171	9168	9164	9159	9152	9143	9132	9120	9106	9091	9074	10
11	9081	9079	9077	9073	9067	9060	9051	9040	9028	9014	8998	8981	11
12	8988	8987	8984	8980	8974	8967	8958	8947	8934	8920	8904	8886	12
13	8893	8892	8890	8886	8880	8872	8862	8851	8838	8824	8807	8789	13
14	8797	8796	8794	8789	8783	8775	8766	8754	8741	8726	8709	8691	14
15	8699	8698	8696	8691	8685	8677	8667	8655	8642	8626	8609	8590	15
16	8600	8599	8596	8591	8585	8577	8567	8555	8541	8525	8507	8488	16
17	8498	8497	8494	8490	8483	8475	8464	8452	8438	8422	8404	8384	17
18	8395	8394	8391	8386	8379	8371	8360	8348	8333	8317	8298	8278	18
19	8289	8288	8285	8280	8274	8265	8254	8241	8226	8209	8190	8169	19
20	8182	8181	8178	8173	8166	8157	8146	8133	8117	8100	8081	8059	20
21	8073	8072	8069	8064	8056	8047	8036	8022	8006	7989	7969	7947	21
22	7961	7960	7957	7952	7945	7935	7923	7909	7893	7875	7855	7832	22
23	7848	7847	7844	7838	7831	7821	7809	7795	7778	7759	7738	7715	23
24	7732	7731	7728	7722	7715	7705	7692	7678	7661	7641	7620	7596	24
25	7615	7613	7610	7604	7596	7586	7573	7558	7541	7521	7499	7474	25
26	7495	7493	7490	7484	7476	7465	7452	7437	7419	7398	7375	7350	26
27	7372	7371	7367	7361	7353	7342	7328	7312	7294	7273	7249	7223	27
28	7247	7246	7242	7236	7227	7216	7202	7186	7167	7145	7121	7094	28
29	7120	7118	7115	7108	7099	7087	7073	7056	7037	7015	6990	6962	29
30	6990	6998	6984	6978	6968	6956	6942	6924	6904	6881	6856	6827	30
31	6857	6856	6852	6845	6835	6823	6808	6790	6769	6745	6719	6689	31
32	6722	6720	6716	6709	6699	6686	6671	6652	6631	6607	6579	6549	32
33	6584	6582	6578	6570	6560	6547	6531	6512	6490	6464	6436	6405	33
34	6443	6441	6436	6429	6418	6405	6388	6368	6345	6319	6290	6258	34
35	6298	6297	6292	6284	6274	6259	6242	6222	6198	6171	6141	6107	35
36	6151	6150	6145	6137	6126	6111	6093	6072	6047	6020	5988	5953	36
37	6001	5999	5994	5986	5974	5959	5941	5919	5893	5864	5832	5796	37
38	5847	5845	5840	5832	5820	5804	5785	5762	5736	5706	5672	5634	38
39	5690	5688	5683	5674	5661	5645	5625	5602	5574	5543	5508	5469	39
40	5529	5527	5522	5513	5500	5483	5462	5438	5409	5377	5341	5300	40
41	5365	5363	5357	5348	5334	5317	5295	5270	5240	5207	5169	5126	41
42	5197	5195	5189	5179	5164	5146	5124	5098	5067	5032	4992	4948	42
43	5024	5022	5016	5006	4991	4972	4949	4921	4889	4853	4812	4766	43
44	4848	4846	4839	4828	4813	4793	4769	4741	4707	4669	4626	4578	44
45	4667	4665	4658	4647	4631	4610	4585	4555	4520	4481	4436	4386	45
46	4482	4479	4472	4461	4444	4423	4396	4365	4329	4287	4240	4188	46
47	4292	4289	4282	4270	4252	4230	4202	4170	4132	4088	4039	3984	47
48	4097	4094	4087	4074	4056	4032	4003	3969	3929	3883	3832	3775	48
49	3897	3894	3886	3872	3853	3829	3799	3763	3721	3673	3619	3559	49
50	3691	3688	3680	3666	3646	3620	3588	3551	3507	3457	3400	3336	50
51	3480	3477	3468	3453	3433	3405	3372	3332	3286	3233	3174	3107	51
52	3263	3260	3251	3235	3213	3184	3149	3108	3059	3003	2940	2869	52
53	3040	3036	3027	3010	2987	2957	2920	2876	2825	2766	2699	2624	53
54	2810	2806	2796	2779	2754	2723	2683	2637	2583	2520	2450	2371	54
55	2573	2570	2559	2540	2514	2481	2440	2390	2333	2267	2192	2108	55
56	2329	2325	2313	2294	2267	2231	2188	2135	2074	2004	1925	1835	56
57	2077	2073	2061	2040	2011	1973	1927	1872	1807	1732	1648	1552	57
58	1817	1813	1800	1778	1747	1707	1658	1599	1530	1450	1360	1257	58
59	1548	1544	1530	1506	1474	1431	1378	1315	1242	1157	1060	0950	59
60	1270	1265	1250	1226	1191	1145	1089	1022	0943	0851	0747	0630	60
61	0982	0977	0961	0935	0897	0848	0788	0716	0631	0533	0421	0294	61
62	0684	0678	0661	0633	0592	0540	0476	0398	0307	0201	0080	9942	62
63	0374	0368	0350	0319	0276	0220	0150	0066	9968	9853	9722	9572	63
64	0052	0046	0026	9993	9946	9886	9810	9720	9613	9489	9346	9182	64

Table (D) MERIDIAN ZENITH-DISTANCE.

Alt.	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	Alt.
5°	9499	9480	9460	9439	9416	9391	9365	9337	9307	9276	9243	9208	5°
6	9413	9394	9374	9352	9328	9303	9276	9248	9218	9186	9152	9117	6
7	9326	9307	9286	9264	9240	9214	9187	9157	9127	9094	9060	9024	7
8	9237	9218	9197	9174	9149	9123	9095	9065	9034	9000	8965	8928	8
9	9147	9127	9106	9082	9057	9030	9002	8971	8939	8905	8869	8831	9
10	9055	9035	9013	8989	8963	8936	8906	8875	8843	8808	8771	8732	10
11	8962	8941	8918	8894	8867	8839	8810	8778	8744	8709	8671	8631	11
12	8866	8845	8822	8797	8770	8741	8711	8678	8644	8607	8569	8528	12
13	8769	8747	8724	8698	8671	8641	8610	8577	8541	8504	8465	8423	13
14	8670	8648	8624	8597	8569	8539	8507	8473	8437	8399	8359	8316	14
15	8569	8546	8522	8495	8466	8435	8403	8368	8331	8291	8250	8207	15
16	8467	8443	8418	8390	8361	8329	8296	8260	8222	8182	8139	8095	16
17	8362	8338	8312	8284	8254	8221	8187	8150	8111	8070	8026	7981	17
18	8255	8230	8204	8175	8144	8111	8076	8038	7998	7956	7911	7864	18
19	8146	8121	8094	8064	8032	7999	7962	7924	7883	7839	7793	7745	19
20	8035	8010	7981	7951	7919	7884	7846	7807	7765	7720	7673	7623	20
21	7922	7896	7867	7836	7802	7767	7728	7687	7644	7598	7550	7498	21
22	7807	7780	7750	7718	7684	7647	7608	7566	7521	7474	7424	7371	22
23	7689	7661	7631	7598	7563	7525	7484	7441	7395	7347	7295	7241	23
24	7569	7541	7509	7476	7439	7400	7359	7314	7267	7217	7164	7108	24
25	7447	7417	7385	7350	7313	7273	7230	7184	7135	7084	7029	6971	25
26	7322	7292	7259	7223	7184	7143	7099	7051	7001	6948	6891	6832	26
27	7195	7163	7129	7092	7052	7010	6964	6915	6864	6809	6750	6689	27
28	7064	7032	6997	6959	6918	6874	6827	6777	6723	6666	6606	6542	28
29	6931	6898	6862	6823	6780	6735	6686	6634	6579	6520	6458	6392	29
30	6796	6761	6724	6683	6640	6593	6542	6489	6432	6371	6306	6238	30
31	6657	6621	6583	6541	6495	6447	6395	6340	6280	6217	6150	6080	31
32	6515	6478	6438	6395	6348	6298	6244	6187	6125	6060	5991	5917	32
33	6370	6332	6291	6246	6197	6145	6090	6030	5967	5899	5827	5750	33
34	6222	6182	6139	6093	6043	5989	5931	5870	5804	5733	5658	5579	34
35	6070	6029	5985	5937	5885	5829	5769	5705	5636	5563	5485	5402	35
36	5915	5872	5826	5777	5723	5665	5602	5536	5464	5388	5307	5221	36
37	5756	5712	5664	5612	5556	5496	5431	5362	5288	5208	5124	5034	37
38	5593	5547	5498	5444	5386	5323	5256	5183	5106	5023	4935	4841	38
39	5426	5379	5327	5271	5211	5145	5075	5000	4919	4832	4740	4642	39
40	5255	5206	5152	5094	5031	4963	4889	4811	4726	4636	4539	4436	40
41	5080	5029	4973	4912	4846	4775	4698	4616	4528	4433	4332	4223	41
42	4900	4846	4788	4725	4656	4581	4501	4415	4323	4223	4117	4003	42
43	4715	4659	4598	4532	4460	4382	4298	4208	4111	4007	3895	3775	43
44	4525	4467	4403	4334	4259	4177	4089	3994	3892	3783	3665	3538	44
45	4330	4269	4203	4130	4051	3965	3873	3773	3666	3550	3426	3292	45
46	4130	4066	3996	3920	3837	3747	3650	3545	3431	3309	3177	3036	46
47	3923	3856	3783	3703	3615	3521	3418	3307	3188	3058	2919	2768	47
48	3710	3640	3563	3479	3387	3287	3179	3062	2935	2797	2649	2489	48
49	3492	3418	3336	3247	3150	3045	2930	2806	2671	2525	2367	2196	49
50	3265	3187	3102	3008	2905	2793	2672	2540	2397	2241	2072	1888	50
51	3032	2950	2859	2760	2651	2532	2403	2263	2110	1943	1762	1564	51
52	2791	2703	2607	2502	2387	2261	2123	1973	1809	1631	1436	1222	52
53	2541	2448	2347	2235	2112	1978	1830	1670	1494	1301	1091	0859	53
54	2282	2184	2076	1956	1825	1682	1524	1351	1162	0954	0725	0472	54
55	2014	1909	1794	1666	1526	1372	1203	1016	0811	0585	0336	0058	55
56	1735	1624	1500	1364	1213	1047	0864	0663	0440	0193	9919	9613	56
57	1445	1326	1193	1047	0885	0705	0507	0288	0044	9773	9470	9129	57
58	1143	1015	0872	0714	0539	0345	0129	9889	9621	9321	8984	8601	58
59	0827	0689	0536	0365	0174	9962	9726	9462	9166	8832	8452	8017	59
60	0497	0348	0182	9996	9788	9556	9296	9003	8673	8297	7865	7362	60
61	0151	9989	9808	9605	9377	9121	8836	8503	8134	7706	7207	6617	61
62	9786	9611	9413	9190	8938	8654	8332	7964	7539	7044	6458	5747	62
63	9402	9210	8992	8467	8467	8149	7785	7365	6874	6291	5584		63
64	8996	8784	8543	8269	7957	7598	7182	6695	6117	5414			64

Table (D). MERIDIAN ZENITH-DISTANCE.

Alt.	24°	25°	26°	27°	28°	29°	30°	31°	32°	33°	34°	35°	Alt.
5°	9172	9134	9094	9052	9008	8962	8915	8865	8813	8759	8703	8645	5
6	9080	9041	9000	8957	8912	8865	8817	8766	8713	8658	8600	8541	6
7	8986	8946	8904	8860	8814	8767	8717	8665	8610	8554	8495	8434	7
8	8889	8849	8806	8761	8714	8666	8614	8561	8506	8448	8388	8325	8
9	8792	8750	8706	8660	8612	8562	8510	8456	8399	8339	8278	8213	9
10	8692	8649	8604	8557	8508	8457	8403	8348	8289	8228	8165	8099	10
11	8590	8546	8500	8452	8402	8349	8294	8237	8177	8115	8050	7982	11
12	8486	8441	8394	8344	8293	8239	8183	8124	8063	7999	7932	7862	12
13	8380	8334	8286	8235	8182	8127	8069	8009	7946	7880	7811	7739	13
14	8271	8224	8175	8123	8069	8012	7953	7890	7826	7758	7687	7613	14
15	8161	8112	8062	8008	7953	7894	7833	7770	7703	7633	7560	7485	15
16	8048	7998	7946	7891	7834	7774	7711	7646	7577	7505	7430	7352	16
17	7932	7881	7828	7772	7713	7651	7586	7519	7448	7374	7297	7216	17
18	7814	7762	7707	7649	7589	7525	7459	7389	7316	7240	7160	7077	18
19	7694	7640	7583	7524	7461	7396	7328	7256	7181	7102	7020	6934	19
20	7570	7515	7457	7396	7331	7264	7193	7119	7042	6961	6875	6786	20
21	7444	7387	7327	7264	7198	7129	7056	6979	6899	6815	6727	6635	21
22	7315	7257	7195	7130	7062	6990	6915	6836	6753	6666	6575	6479	22
23	7183	7123	7059	6992	6922	6847	6770	6688	6602	6512	6418	6319	23
24	7048	6986	6920	6851	6778	6701	6621	6536	6447	6354	6256	6153	24
25	6910	6846	6778	6706	6631	6551	6468	6380	6288	6191	6090	5983	25
26	6768	6702	6632	6558	6479	6397	6311	6220	6124	6024	5918	5807	26
27	6623	6554	6482	6405	6324	6239	6149	6055	5956	5851	5741	5625	27
28	6475	6403	6328	6248	6165	6076	5983	5885	5782	5673	5558	5437	28
29	6322	6248	6170	6087	6000	5909	5812	5710	5602	5488	5368	5242	29
30	6165	6089	6007	5922	5831	5736	5635	5529	5416	5298	5172	5040	30
31	6004	5925	5841	5752	5657	5558	5453	5342	5225	5101	4969	4830	31
32	5839	5756	5669	5576	5478	5374	5265	5149	5026	4896	4758	4612	32
33	5669	5583	5492	5395	5293	5185	5070	4949	4820	4684	4539	4386	33
34	5494	5405	5310	5209	5102	4989	4869	4742	4607	4463	4311	4149	34
35	5314	5221	5122	5016	4905	4786	4660	4527	4385	4234	4073	3902	35
36	5129	5031	4928	4817	4701	4576	4444	4304	4154	3995	3825	3643	36
37	4938	4836	4727	4612	4489	4359	4219	4071	3913	3745	3564	3371	37
38	4740	4634	4520	4399	4270	4132	3986	3829	3662	3483	3292	3085	38
39	4537	4425	4305	4178	4042	3897	3742	3576	3399	3209	3004	2784	39
40	4326	4208	4082	3948	3805	3652	3488	3312	3123	2920	2701	2464	40
41	4108	3984	3851	3710	3558	3396	3222	3034	2833	2615	2380	2124	41
42	3881	3751	3611	3461	3300	3128	2942	2742	2527	2293	2039	1761	42
43	3646	3508	3361	3202	3031	2847	2649	2435	2202	1950	1674	1372	43
44	3402	3256	3099	2930	2748	2552	2339	2109	1858	1584	1283	0952	44
45	3148	2993	2826	2646	2451	2240	2012	1763	1490	1191	0861	0494	45
46	2883	2718	2539	2347	2138	1911	1664	1393	1096	0767	0402	9992	46
47	2605	2429	2239	2032	1807	1561	1293	0997	0671	0307	9898	9435	47
48	2315	2126	1921	1699	1455	1188	0895	0570	0208	9801	9340	8809	48
49	2009	1807	1586	1345	1080	0789	0465	0105	9701	9241	8712	8092	49
50	1688	1469	1230	0968	0678	0357	9999	9596	9138	8611	7993	7252	50
51	1348	1111	0851	0564	0245	9889	9488	9032	8507	7891			51
52	0988	0730	0445	0128	9774	9376	8922	8398	7784	7047			52
53	0604	0321	0007	9655	9259	8807	8286	7674	6938	6024			53
54	0192	9881	9532	9138	8688	8169	7559	6826	5914	4721			54
55	9749	9403	9011	8565	8048	7440	6709	5800	4608	2905			55
56	9269	8880	8436	7922	7317	6588							56
57	8743	8302	7790	7188	6462	5557							57
58	8162	7654	7054	6331	5428								58
59	7511	6914	6194	5294									59
60	6769	6051	5155										60
61	5902												61

Table (D). MERIDIAN ZENITH-DISTANCE.

Alt.	36°	37°	38°	39°	40°	41°	42°	43°	44°	45°	46°	47°	Alt.
5°	8585	8522	8456	8388	8318	8245	8169	8090	8008	7924	7835	7744	5°
6	8479	8414	8347	8278	8205	8130	8052	7972	7887	7800	7709	7615	6
7	8371	8304	8236	8164	8090	8013	7933	7850	7763	7673	7580	7483	7
8	8260	8192	8121	8048	7972	7893	7810	7725	7636	7543	7447	7347	8
9	8146	8077	8004	7929	7851	7769	7684	7596	7504	7409	7310	7206	9
10	8030	7959	7884	7807	7726	7642	7555	7464	7369	7271	7168	7062	10
11	7911	7838	7761	7681	7599	7512	7422	7328	7231	7129	7023	6912	11
12	7789	7714	7635	7553	7467	7378	7285	7189	7088	6983	6873	6759	12
13	7665	7587	7506	7421	7333	7241	7145	7045	6941	6832	6718	6600	13
14	7537	7456	7373	7285	7194	7099	7000	6897	6789	6676	6558	6435	14
15	7405	7322	7236	7146	7052	6954	6851	6744	6632	6516	6393	6265	15
16	7270	7185	7096	7003	6906	6804	6698	6587	6471	6350	6222	6089	16
17	7132	7044	6952	6855	6755	6650	6540	6425	6304	6178	6045	5907	17
18	6990	6899	6803	6704	6599	6490	6376	6257	6131	6000	5862	5717	18
19	6844	6749	6651	6547	6439	6326	6207	6083	5952	5815	5671	5520	19
20	6693	6596	6493	6386	6274	6156	6033	5903	5767	5624	5473	5315	20
21	6538	6437	6331	6220	6103	5981	5852	5717	5575	5425	5267	5100	21
22	6379	6274	6164	6048	5927	5799	5665	5524	5375	5218	5052	4877	22
23	6215	6106	5991	5870	5744	5611	5470	5323	5167	5002	4828	4643	23
24	6045	5932	5812	5687	5555	5415	5269	5114	4950	4777	4593	4397	24
25	5870	5752	5628	5497	5358	5213	5059	4896	4723	4541	4346	4139	25
26	5690	5566	5436	5299	5154	5002	4840	4668	4487	4293	4087	3867	26
27	5502	5374	5238	5094	4942	4782	4611	4430	4238	4033	3814	3580	27
28	5309	5174	5032	4881	4721	4552	4372	4181	3977	3759	3525	3274	28
29	5108	4967	4817	4659	4491	4312	4122	3919	3702	3469	3219	2949	29
30	4900	4751	4594	4427	4249	4060	3859	3643	3411	3162	2893	2601	30
31	4683	4527	4361	4185	3997	3796	3581	3351	3103	2835	2544	2226	31
32	4458	4293	4118	3931	3731	3518	3288	3041	2774	2484	2168	1821	32
33	4222	4048	3863	3664	3452	3224	2978	2712	2423	2108	1761	1379	33
34	3976	3792	3595	3384	3157	2912	2647	2359	2045	1700	1318	0892	34
35	3719	3523	3313	3087	2844	2580	2293	1981	1636	1256	0831	0351	35
36	3448	3240	3015	2773	2511	2225	1913	1571	1191	0767	0289	9741	36
37	3164	2941	2700	2439	2154	1844	1502	1124	0701	0224	9677	9041	37
38	2864	2624	2364	2081	1772	1432	1055	0633	0157	9612	8976	8217	38
39	2545	2287	2006	1698	1359	0983	0562	0087	9543	8909	8152		39
40	2207	1927	1620	1283	0908	0489	0016	9473	8840	8083			40
41	1846	1540	1204	0831	0413	9941	9399	8768	8013				41
42	1458	1123	0751	0335	9864	9324	8693	7940					42
43	1039	0668	0254	9784	9245	8616	7864						43
44	0583	0169	9701	9164	8536	7785							44
45	0082	9616	9080	8453	7704								45
46	9527	8993	8368	7620									46
47	8902	8279	7533										47
48	8187	7442	6520										48
49	7349	6428											49
50	6332												50

Table (D). MERIDIAN ZENITH-DISTANCE.

Alt.	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°	Alt.
5°	7649	7550	7448	7341	7231	7115	6995	6870	6740	6604	6462	6313	5°
6	7517	7416	7310	7200	7085	6966	6842	6712	6577	6436	6288	6133	6
7	7382	7277	7168	7054	6935	6812	6683	6549	6408	6261	6107	5946	7
8	7242	7134	7021	6903	6781	6652	6519	6379	6233	6080	5919	5750	8
9	7099	6986	6870	6748	6620	6487	6348	6203	6050	5891	5723	5546	9
10	6950	6834	6713	6587	6454	6316	6171	6020	5861	5694	5518	5332	10
11	6797	6677	6551	6420	6282	6138	5988	5829	5663	5488	5303	5109	11
12	6639	6514	6384	6247	6104	5954	5796	5631	5457	5273	5079	4873	12
13	6476	6346	6210	6068	5919	5762	5597	5424	5241	5047	4843	4625	13
14	6306	6171	6030	5882	5726	5562	5389	5207	5014	4810	4594	4364	14
15	6131	5991	5843	5688	5525	5353	5171	4980	4777	4561	4331	4086	15
16	5949	5803	5648	5486	5315	5135	4944	4741	4526	4298	4053	3791	16
17	5761	5607	5446	5276	5096	4906	4704	4490	4262	4019	3758	3477	17
18	5564	5404	5235	5056	4866	4666	4452	4225	3983	3722	3442	3139	18
19	5360	5192	5014	4825	4625	4413	4187	3945	3685	3406	3104	2775	19
20	5147	4970	4782	4583	4372	4146	3905	3647	3368	3067	2739	2381	20
21	4924	4738	4540	4329	4104	3864	3606	3329	3028	2701	2344	1950	21
22	4691	4494	4284	4060	3821	3564	3287	2988	2662	2305	1912	1475	22
23	4447	4238	4015	3776	3520	3245	2946	2621	2265	1873	1436	0945	23
24	4190	3968	3730	3475	3200	2902	2578	2223	1831	1396	0905	0346	24
25	3918	3682	3428	3153	2857	2533	2179	1789	1354	0864	0306	9658	25
26	3632	3378	3105	2809	2487	2134	1744	1310	0821	0264	9616	8846	26
27	3327	3055	2760	2439	2086	1697	1264	0777	0220	9574	8804		27
28	3003	2709	2388	2037	1649	1217	0730	0175	9529	8760			28
29	2656	2336	1986	1599	1168	0682	0127	9482	8715				29
30	2282	1933	1547	1117	0632	0078	9434	8667					30
31	1878	1493	1064	0580	0027	9384	8618						31
32	1437	1008	0526	9974	9332	8567							32
33	0951	0470	9919	9278	8514								33
34	0412	9862	9222	8459									34
35	9803	9164	8402										35
36	9103	8343											36
37	8281												37

Table (D). MERIDIAN ZENITH-DISTANCE.

Alt.	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°	71°	Alt.
5°	6158	5995	5824	5645	5456	5256	5046	4823	4586	4333	4063	3773	5°
6	5971	5801	5622	5434	5235	5025	4803	4567	4315	4046	3756	3445	6
7	5776	5598	5411	5213	5004	4782	4546	4295	4027	3738	3427	3090	7
8	5573	5386	5189	4981	4760	4525	4274	4006	3719	3408	3072	2704	8
9	5360	5164	4956	4736	4502	4252	3985	3698	3388	3052	2685	2282	9
10	5137	4930	4710	4477	4228	3961	3675	3366	3031	2665	2263	1816	10
11	4902	4683	4451	4203	3937	3651	3343	3009	2643	2242	1796	1296	11
12	4655	4423	4176	3911	3626	3318	2985	2620	2219	1774	1275	0706	12
13	4394	4147	3883	3599	3292	2959	2596	2195	1751	1252	0685	0027	13
14	4118	3854	3571	3265	2933	2570	2170	1726	1228	0661	0004	9224	14
15	3823	3541	3236	2904	2542	2143	1700	1203	0637	9980	9201		15
16	3509	3206	2874	2513	2115	1673	1176	0611	9955	9177			16
17	3173	2843	2482	2085	1643	1148	0583	9928	9151				17
18	2810	2450	2054	1613	1118	0554	9900	9123					18
19	2416	2020	1581	1086	0523	9870	9094						19
20	1986	1547	1054	0491	9839	9063							20
21	1512	1019	0457	9806	9031								21
22	0983	0422	9771	8997									22
23	0385	9735	8962										23
24	9697	8925											24
25	8886												25

Table (D). MERIDIAN ZENITH-DISTANCE.

Alt.	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	Alt
5°	3461	3122	2753	2347	1897	1392	0819	0156	9370				5°
6	3107	2738	2333	1883	1380	0807	0144	9359					6
7	2722	2317	1869	1366	0794	0132	9347						7
8	2300	1853	1350	0779	0118	9334							8
9	1835	1333	0763	0102	9319								9
10	1315	0745	0086	9303									10
11	0727	0067	9285										11
12	0048	9267											12
13	9246												13
14													14

Table (D). MULTIPLIERS FOR MINUTES OF ALTITUDE.

Min.	0′	1′	2′	3′	4′	5′	6′	7′	8′	9′	10′
0	·00	·02	·03	·05	·07	·08	·10	·12	·13	·15	·17
10	·17	·18	·20	·22	·23	·25	·27	·28	·30	·32	·33
20	·33	·35	·37	·38	·40	·42	·43	·45	·47	·48	·50
30	·50	·52	·53	·55	·57	·58	·60	·62	·63	·65	·67
40	·67	·68	·70	·72	·74	·75	·77	·78	·80	·82	·83
50	·83	·85	·87	·88	·90	·92	·93	·95	·97	·98	1·00

Table (E). LATITUDE.

Bearing.	0°	4°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
10	5·67	5·70	5·73	5·76	5·79	5·85	5·91	5·97	6·03	6·12	6·21	6·30	6·42	6·55	6·69
12	4·71	4·72	4·75	4·78	4·81	4·85	4·89	4·95	5·01	5·08	5·16	5·28	5·34	5·43	5·55
14	4·01	4·02	4·04	4·06	4·09	4·12	4·16	4·20	4·26	4·32	4·38	4·46	4·54	4·63	4·73
16	3·49	3·50	3·52	3·54	3·56	3·59	3·62	3·66	3·70	3·76	3·82	3·88	3·94	4·02	4·11
18	3·08	3·09	3·11	3·13	3·15	3·18	3·20	3·24	3·28	3·32	3·37	3·43	3·49	3·55	3·63
20	2·75	2·76	2·78	2·79	2·81	2·83	2·86	2·89	2·92	2·96	3·01	3·06	3·12	3·17	3·24
22	2·47	2·47	2·48	2·50	2·52	2·54	2·57	2·60	2·63	2·66	2·70	2·75	2·80	2·86	2·92
24	2·25	2·26	2·27	2·28	2·30	2·32	2·34	2·37	2·39	2·43	2·46	2·50	2·55	2·59	2·65
26	2·05	2·05	2·07	2·08	2·10	2·11	2·13	2·15	2·18	2·21	2·24	2·28	2·32	2·37	2·42
28	1·88	1·88	1·90	1·91	1·92	1·94	1·96	1·98	2·00	2·03	2·06	2·09	2·13	2·17	2·22
30	1·73	1·73	1·75	1·76	1·77	1·78	1·80	1·82	1·84	1·87	1·89	1·92	1·96	2·00	2·04
32	1·60	1·60	1·62	1·63	1·64	1·65	1·66	1·68	1·70	1·73	1·75	1·78	1·81	1·85	1·89
34	1·48	1·48	1·49	1·50	1·51	1·53	1·54	1·56	1·57	1·60	1·62	1·65	1·68	1·71	1·75
36	1·38	1·38	1·39	1·40	1·41	1·42	1·44	1·45	1·47	1·49	1·51	1·53	1·55	1·59	1·62
38	1·28	1·28	1·28	1·29	1·30	1·31	1·32	1·34	1·35	1·37	1·39	1·41	1·44	1·48	1·51
40	1·19	1·19	1·20	1·21	1·22	1·23	1·24	1·25	1·27	1·28	1·30	1·32	1·35	1·38	1·41
42	1·11	1·11	1·12	1·13	1·14	1·14	1·15	1·17	1·18	1·20	1·22	1·24	1·26	1·28	1·31
44	1·04	1·04	1·04	1·05	1·06	1·07	1·08	1·09	1·10	1·12	1·13	1·15	1·17	1·20	1·22
46	0·97	0·97	0·98	0·98	0·99	1·00	1·01	1·02	1·03	1·04	1·06	1·07	1·09	1·11	1·14
48	0·90	0·90	0·91	0·91	0·92	0·93	0·94	0·95	0·96	0·97	0·99	1·00	1·02	1·04	1·06
50	0·84	0·84	0·85	0·85	0·86	0·87	0·87	0·88	0·89	0·91	0·92	0 93	0·95	0·97	0·99
52	0·78	0·78	0·79	0·79	0·80	0·80	0·81	0·82	0·83	0·84	0·85	0·87	0·88	0·90	0·92
54	0 73	0·73	0·73	0·74	0·74	0·75	0·75	0·76	0·77	0·78	0·79	0 81	0·82	0·84	0·86
56	0·67	0·67	0·68	0·68	0·69	0·69	0·70	0·71	0.71	0·72	0·73	0·75	0·77	0·78	0·79
58	0·63	0·63	0·63	0·63	0·64	0·64	0·65	0·66	0·66	0·67	0·68	0·69	0·71	0·72	0·74
60	0·58	0·58	0·59	0·59	0·59	0·60	0·60	0·61	0·62	0·62	0·63	0 65	0·66	0·67	0·68
62	0·53	0·53	0·54	0·54	0·54	0·55	0·55	0·56	0·56	0·57	0·58	0·59	0·60	0·61	0·63
64	0·49	0·49	0·50	0·50	0·50	0·51	0·51	0·52	0·52	0·53	0·54	0·55	0·56	0·56	0·57
66	0·45	0·45	0·45	0·45	0·46	0·46	0·46	0·47	0·47	0·48	0·49	0·50	0·50	0·51	0·52
68	0·40	0·40	0·40	0·41	0·41	0·41	0·42	0·42	0·43	0·43	0·44	0·45	0 45	0·47	0·47
70	0·36	0·36	0·36	0·37	0·37	0·37	0·37	0·38	0·38	0·39	0·39	0·40	0·41	0·42	0·43
72	0·33	0·33	0·33	0·33	0·34	0·34	0·34	0·34	0·35	0·35	0·36	0·36	0·37	0·37	0·38
74	0·29	0·29	0·29	0·29	0·30	0·30	0 30	0·31	0·31	0·31	0·32	0·32	0·33	0·33	0·34
76	0·25	0·25	0·25	0·25	0·25	0·26	0·27	0·27	0·27	0·27	0·27	0·28	0·28	0·29	0·29
78	0 21	0·21	0·21	0·21	0·21	0·22	0 22	0·22	0 22	0·23	0·23	0·23	0·23	0·24	0·25
80	0·18	0·18	0·18	0·18	0·18	0·18	0·18	0·18	0·19	0·19	0·19	0·20	0 20	0·20	0·21
82	0·14	0·14	0·14	0·14	0·14	0·14	0·14	0·15	0·15	0·15	0·15	0·15	0·15	0·16	0·17
84	0·10	0·10	0·10	0·10	0·10	0·10	0·11	0·11	0·11	0·11	0·11	0·11	0·11	0·12	0·12
86	0·07	0·07	0·07	0·07	0·07	0·07	0·07	0·07	0·08	0·08	0·08	0·08	0·08	0·08	0·08
88	0·03	0·03	0·03	0·04	0·04	0·04	0 04	0·04	0·04	0·04	0·04	0·04	0·04	0·04	0·04
89	0·01	0·01	0·01	0·02	0 02	0·02	0·02	0·02	0·02	0·02	0·02	0·02	0·02	0·02	0·02
90	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00

Bearing.	Table (E). LATITUDE.														Corr. for 1′ of Alt. at the Equator.
	° 34	° 36	° 38	° 40	° 42	44	° 46	° 48	° 50	° 52	° 54	° 56	° 58	° 60	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
10	6·84	7·01	7·20	7·40	7·63	7·88	8·16	8·48	8·82	9·21	9 65	10·14	10·70	11·33	5·76
12	5·67	5·81	5·97	6·14	6·33	6·54	6·77	7·03	7·32	7·64	8·00	8·41	8·88	9·41	4·70
14	4·84	4·95	5·09	5·23	5·40	5·58	5·77	5·99	6·24	6·51	6·82	7·17	7·57	8·02	4·13
16	4·21	4·31	4·43	4·55	4·69	4·85	5·02	5·21	5·42	5·66	5·93	6·24	6·58	6·97	3 63
18	3·71	3·80	3·90	4·02	4·14	4·28	4·43	4·60	4·79	5·00	5·24	5·50	5·81	6·15	3·24
20	3·31	3·39	3·49	3·59	3·70	3·82	3·95	4·11	4·27	4·46	4·67	4·91	5·19	5·49	2·92
22	2·98	3·06	3·14	3·23	3·33	3·44	3·56	3·70	3·85	4·02	4·21	4·43	4·67	4·95	2·67
24	2·71	2·77	2·85	2·93	3·02	3·12	3·23	3·36	3·49	3·65	3·82	4·02	4·24	4·49	2·46
26	2·47	2·53	2·60	2·68	2·76	2·85	2·95	3·06	3·19	3·33	3·49	3·66	3·87	4·10	2·28
28	2·27	2·32	2·39	2·45	2·53	2·61	2·71	2·81	2·92	3·05	3·20	3·36	3·55	3 76	2·13
30	2·09	2·14	2·20	2·26	2·33	2·41	2·49	2·60	2·69	2·81	2·95	3·10	3·27	3·46	2·00
32	1·93	1·98	2·03	2·09	2·15	2·22	2·30	2·39	2·49	2·60	2·72	2·86	3·02	3·20	1·89
34	1·79	1·83	1·88	1·93	1·99	2·06	2·13	2·22	2·31	2·41	2·52	2·65	2·80	2·96	1·79
36	1·66	1·70	1·74	1·80	1·85	1·91	1·98	2·06	2·14	2·24	2·34	2·46	2·60	2·75	1·70
38	1·54	1·58	1·62	1·67	1·72	1·78	1·84	1·91	1·99	2·08	2·18	2·29	2·41	2·56	1·62
40	1·44	1·47	1·51	1·55	1·60	1·66	1·72	1·78	1·85	1·94	2·03	2·13	2·25	2·38	1·56
42	1·34	1·37	1·41	1·45	1·49	1·54	1·60	1·66	1·73	1·80	1·89	1·99	2·09	2·22	1·49
44	1·25	1·28	1·31	1·35	1·39	1·44	1·49	1·55	1·61	1·68	1·76	1·85	1·95	2·07	1·44
46	1·16	1·19	1·23	1·26	1·30	1·34	1·39	1·44	1·50	1·56	1·64	1·73	1·82	1.93	1·39
48	1·09	1·11	1·14	1·17	1·21	1·25	1·30	1·35	1·40	1·46	1·53	1·61	1·70	1·80	1·35
50	1·01	1·04	1·06	1·09	1·13	1·16	1·21	1·25	1·31	1·36	1·43	1·50	1·58	1·68	1·31
52	0·94	0·96	0·99	1·01	1·05	1·09	1·12	1·17	1·22	1·27	1·33	1·40	1·47	1·56	1·27
54	0·88	0·90	0·92	0·95	0·98	1·01	1·04	1·09	1·13	1·18	1·23	1·30	1·37	1·45	1·24
56	0·81	0·83	0·85	0·88	0·91	0·94	0·97	1·01	1·05	1·10	1·15	1·21	1·27	1·35	1·21
58	0.75	0·77	0·79	0·81	0·84	0·87	0·90	0·93	0·97	1·01	1·06	1·12	1·18	1·25	1·18
60	0·70	0·71	0·73	0·75	0·78	0·80	0·83	0·86	0·90	0·94	0·98	1·03	1·09	1·15	1·15
62	0·64	0·66	0·67	0·69	0·72	0·74	0·76	0·79	0·83	0·86	0·90	0·95	1·00	1·06	1·13
64	0·59	0·60	0·62	0·64	0·66	0·68	0·70	0·73	0·76	0·79	0·83	0·87	0·92	0·97	1·11
66	0·54	0·55	0·56	0·58	0·60	0·62	0·64	0·66	0·69	0·72	0·76	0·79	0·84	0·89	1·09
68	0·49	0·50	0·51	0·53	0·54	0·56	0·58	0·60	0·63	0·65	0·69	0·72	0·76	0·81	1·08
70	0·44	0·45	0·46	0·47	0·49	0·51	0·52	0·54	0·57	0·59	0·62	0 65	0·68	0·73	1·06
72	0·39	0·40	0·41	0·42	0·44	0·45	0·47	0·49	0·51	0·53	0 55	0·58	0·61	0·65	1·05
74	0·34	0·36	0·36	0·37	0·38	0·40	0 41	0·43	0·44	0·46	0·49	0·52	0·54	0·57	1·04
76	0·30	0·31	0·31	0·32	0·33	0·34	0·36	0·37	0·39	0·40	0·42	0·45	0·47	0·50	1·03
78	0·25	0.26	0·27	0·28	0·29	0·29	0·30	0·32	0 33	0·34	0·36	0·38	0·40	0·42	1·02
80	0 21	0·22	0·22	0·23	0·24	0·24	0·25	0·26	0·27	0·29	0·30	0·31	0·33	0·35	1·02
82	0 17	0·17	0·18	0 18	0·19	0·19	0·20	0·21	0·22	0·23	0·24	0·25	0·26	0·28	1·01
84	0·13	0·13	0·13	0.14	0·14	0·14	0·15	0·16	0·16	0·17	0·18	0·19	0·20	0·21	1·01
86	0·08	0·08	0·09	0·09	0·09	0·10	0·10	0·10	0·11	0·11	0 12	0·12	0·13	0·14	1·00
88	0·04	0·04	0·04	0·04	0·05	0·05	0·05	0·05	0·05	0·06	0·06	0 06	0·07	0·07	1·00
89	0·02	0·02	0·02	0 02	0·02	0.02	0·02	0·03	0·03	0·03	0·03	0·04	0·05	0·05	1·00
90	0·00	0 00	0·00	0·00	0·00	0·00	0·00	0 00	0·00	0·00	0·00	0·00	0·00	0·00	1·00

NOTES.

I.—If it be desired to take more than one altitude in the manner directed on page 5, set the sextant first at 30° − 11′, and secondly at 30° + 11′, when the Mean of the two will be 30°, as required. This applies to A.M. sights: For P.M. we must begin with the greatest altitude and proceed in like manner.

To take four altitudes, set the sextent at 30° − 22′, 30° − 11′, 30° + 11′ and 30° + 22′, for A.M. sights; and in the reverse order for P.M. observations.

II.—Application of Tables A, B, C, to finding the Altitude Azimuth.

(*a*) *Lat. and Dec. of same name:* Take difference of lat. and alt.

(*b*) *Lat. and Dec. of contrary names:* Take sum of lat and alt.

For North declination, take N.P.D. and reckon Azimuth from North. For South declination, take S.P.D. and reckon Azimuth from South, and proceed as in finding the time.

Example I., A.M.

Lat. 23° 45′ N., Alt. 21° 42′, Dec. 20° 49′ N.

	Lat.	23° 45′ N.	384
Tab. A.	Alt.	21 42	319
6	Diff.	2 3	
6446	N.P.D.	69 11	
6440	4h.	36m. 36s.	8090
	*5h.	3m. 48s.	8793

∴ Az. = N. 75° 57′ E.

Example II., P.M.

Lat. 25° 31′ N, Dec. 14° 47′ S, Alt. 15° 46′

	Lat.	25° 31′ N.	446
Tab. A.	Alt.	15 46	166
2486	Sum	41 17	
7449	S.P.D.	75 13	
4963	3h.	59m. 2s.	6958
	*4h.	18m. 30s.	7570

∴ Az. = S. 64° 37½′ W.

When the Azimuth exceeds the limit of Table (B), which it can only do when latitude and declination are of the same name, substract the *sum* of lat. and alt. from 180°, and proceed as before, marking the Azimuth with the *contrary* name to the declination.

III.—To find the time of sunset and sunrise by the same Tables; proceed as in the following Examples:

	Lat.	10°	35′	N.	74
Tab. A.	Dec.	23	23	S.	372
1706	M.Z.	33	58		
10000	Z.D.	90	0		
8294	5h.	20m.	41s.		9187
Sunset	5	41	24	P.M.	9633
Sunrise	6	18	36	A.M.	

IV.—To find the Azimuth at rising or setting, make the Altitude 0°, and proceed as in Examples I and II. above,

* Thus 5h. 3m. 48s. = 303m. 48s., which divided by 4 = 75° 57′;
and 4h. 18m. 30s. = 258m. 30s., which divided by 4 = 64° 37½′.

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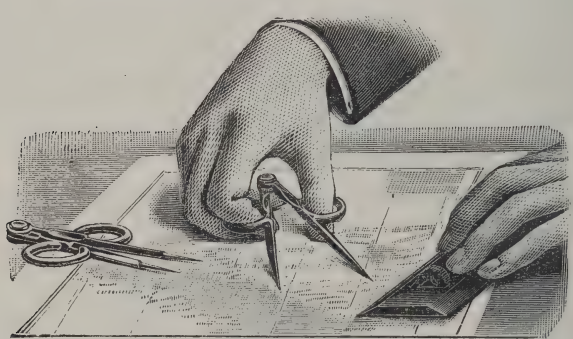

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	1885	1890	1895	1900	1905
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Chart Plates Improved by Additional Plans ...	32	10	34	30	36
Chart Plates Improved by Corrections and Additions	186	130	163	224	196
Corrections Made to the Chart Plates	2,750	4,750	5,300	4,520	5,320
Minor Corrections at the hands of the Draughtsmen	29,800	37,270	30,096	35,500	60,499
Total Number of Charts Printed	272 115	297,120	312,638	580,207	689,930